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Best Practice in the General Use of Data in a City

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Abstract

This chapter gives a "bird's eye view" of a variety of examples of how some of the "EU CITIES MISSION's 100 climate neutral and smart cities by 2030" are already using data from a wide variety of sources. They collectively will

bring a wide range of experiences to ensure that the identified good practices in data usage might be shared and built upon, in the drive to make data work to drive forward the climate-neutral agenda.[1]

The examples come from a wide range of application areas and reflect the variety of the emerging data spaces, with the majority coming from the "100 climate-neutral cities". Whilst useful in its own right to be able to see the variety of uses data is being put to in a city, to stimulate ideas and potential replication elsewhere, the main purpose is for it to be used as a building block. The following chapter will concentrate on how cities have used personal data in the process of running their city. But in addition to providing these examples, we will also try to indicate how, by adding personal data to the data currently being used in the cases described in this chapter, added value might be demonstrated.

3.1 Flanders, Belgium

Flanders can be seen as a network of interrelated cities forming together with Brussels a large metropolis area, along with cities such as Antwerp, Bruges, Leuven, and Ghent. Flanders alone can be considered as one single, smart region of 6.7 million people. The smart Flanders network brings the region together to create the necessary scale for smart city solution and data providers. It is anticipated that a Flanders digital twin will play a crucial role to open and democratise available smart city data to citizens, companies, and service providers and to use for co-created policy. Flanders started from its spatial data infrastructure and early digital twin prototyping.

The overall goals for taking a digital twin approach are to:

- create a smart region where all players can access available services and data;
- support cross-silo cooperation between sectors;
- involve citizens and companies active in policy-making processes to improve the quality of decision-making and acceptance of the outcomes;
- set up transferable services and data standards to maximise efficiency and open the market.

[1] "100 Climate-neutral Cities by 2030 – by and for the Citizens ," *European Commission*. https://ec.europa.eu/info/publications/100-climate-neutral-cities-2030-and-citizens_en (accessed Jul. 25, 2022).

In terms of the specific policy goals which the Flanders DUET Project Digital Twin[2] will concentrate on will be: "The design of new measures and the implementation of actions and evaluation of the success of actions foreseen in the Flanders Regional Mobility Plan, and in the Flanders Environment Plan which both aim for smoother mobility through actions that are kinder to the environment and which reduce the impact on human health". These regional plans are translated to specific measures on the local level that can be part of a DUET Digital Twin simulation.

"Currently, Flanders is a European hot spot for air pollution. Alternatives to car transport have been put in place to increase the daily level of physical activity among the population and reduce air pollution and global warming. To evaluate the impact of existing measures and help create new ones, Flanders will test and implement the Digital Twin to ingest and use vast amounts of data to help the city and its stakeholders explore correlations between the mobility, health and air data".

A practical example can be seen in the simulation of what might occur if a specific bridge were to be closed in GHENT – what would be the implications on the traffic and the feelings of the local population were this to happen – and hence what would be the effect on achieving the policy goal of reducing air pollution.

Flanders is also experimenting with SOLID.[3]

3.2 Pilsen, Czech Republic

Pilsen with a population of over 165,000 as such is a good example of medium sized European city. It has its industrial activity and acts as a centre for retail and entertainment whilst acting as an important hub for commuters and attracting tourists and visitors. In keeping with other similar sized cities, Pilsen faces significant challenges in the process of designing how the city will progress and in dealing with transport planning. In moving towards being a smart city, it is developing and implementing solutions in a variety of areas and these include mobility, security, business support, environment, ICT, and public participation. Pilsen has a wide range of datasets, GIS, and traffic modelling tools but not from an integrated solution.

[2] "Flanders Twin - DUET: Digital Urban European Twins." https://www.digitalurbantwins.com/flanderstwin (accessed Jul. 25, 2022).

[3] "Solid: Your data, your choice." https://solidproject.org/ (accessed Jul. 22, 2022).

Pilsen's motive for joining the DUET project[4] is similar to that of Athens. Pilsen is faced with a lack of complex and data-based planning across different sectors and policy areas that influence each other, hence the adoption of the digital twin approach. Its initial focus in creating its digital twin will be the interrelationship between transport and noise pollution in a 3D environment. Noise pollution in the city environment is influenced by many factors. A significant factor is the local road transport and especially the traffic volumes that pass by the built-up environment, the types of vehicles, and traffic conditions such as speed limits. Whereas, the other factors that play a crucial role in the city ecosystem are the overall urban design, urban morphology, land use, street distribution, street environment, and green infrastructure.

In relation to the city's policy goals, a driving force behind using digital twins is to help achieve the city's overall goals and, in particular, the issue of reducing noise pollution.

Pilsen is demonstrating the digital twin concept across transport and mobility, urban planning, and environment and wellbeing by focusing on two related policy areas:

- Environmental Noise Directive (2002/49/EC) which recognises the need to protect quiet areas in cities and towns as sites of value to the local community. Plants and specific land use can play a role in this by softening the urban environment and reducing noise.
- The development of Pilsen's sustainable mobility plan. Stress will be made on the interrelation of these policy areas, breaking the silo-based traditional approaches in decision-making.

3.3 Camden, London, United Kingdom

Open data policies for citizens:

The Camden Plan is the council's response to the Camden 2025 vision. This is our plan for how we, as an organisation, will play our part to achieve the ambitions set out in Camden 2025. It reaffirms our values and ambitions and shows how we will work with our communities to take forward our shared priorities over the next four years, between 2018 and 2022. This means working together to make sure that Camden stays an amazing place to live, work, and grow up, where everyone can lead happy, healthy, and fulfilling lives.

[4] "Pilsen Twin - DUET: Digital Urban European Twins." https://www.digitalurbantwins.com/pilsen-twin (accessed Jul. 25, 2022).

With a population of, 210,100 the London Borough of Camden is one of the 12 boroughs of inner London. The southern tip of Camden forms a small section of Central London.

The Council[5,6] will address social services policy planning in Camden by predicting risk factors across four distinct domains:

- housing and adult social care;
- children, schools, and families;
- culture and environment planning;
- building and parking services.

The Council is committed to the publication of open data and adheres to the Council Open Data Charter which is underpinned by the notion that residents have the right to access data which does not compromise individual privacy.

The plan is to apply predictive analytics techniques to data sourced from the target domains in order to identify risk factors across the full range of services offered by the Council. Examples of information to be obtained using these techniques include the following.

The extent of the relationship between housing repairs required and other higher cost services such as social work. Such information would enable the Council to identify potential cases where early intervention in one area could prevent cost escalation in another, related area.

- Car licensing data. Providing this information to the parking services department would enable planning for temporary events which might require additional resourcing.
- Data that enables forecasting of the numbers of people requiring adult social care services in future, principally older people, in order to plan future services.
- A comprehensive overview of the totality of each resident's interactions with the Council.
- The extent of the relationship between housing repairs required and other higher cost services such as social work. Such information would enable the Council to identify potential cases where early intervention in one area could prevent cost escalation in another, related area.

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[5] "Open Data Policies for Citizens: Camden - Policy Cloud." https://policycloud.eu/pilots/open-data-policies-citizens (accessed Jul. 25, 2022).

[6] "Deliverables - Policy Cloud." https://policycloud.eu/publications/deliverables?field_wp_tid%5B%5D=7 (accessed Jul. 25, 2022).

Using the information harvested from data analytics, the Council will be able to design evidence-based policies and evaluate their economic feasibility, their political viability, and their legitimacy, thereby improving the quality of the services offered to citizens and achieving the efficiency and effectiveness which are key elements of good governance.

3.4 Trikala, Greece

Trikala was a demonstration site for the EU ELVITEN project – electrified L-category vehicles integrated into transport and electricity networks.

During the 6 months' demonstration period of the Horizon 2020 Project – ELVITEN, all trip data of the end-users (citizens and professionals) using EL-Vs (light electric vehicles) in Trikala were collected from the project's fleet management platform. The EL-Vs used were electric quad and three wheelers and electric bicycles and had special black boxes installed to gather data. All these anonymised trip data were transferred to the Municipality's open data platform in order to be available to companies, organisations, universities, and cities that are planning to implement mobility projects in the near future.

The types of data which were utilised included the following: trip data of electric vehicle users, vehicle speed, location data, trip times, battery level, and energy consumption.

The end-users of the EL-Vs were using a smartphone application in order to book the vehicle and to track and record all the critical data, such as vehicle real-time location, speed, time of trip, and energy consumption of every single trip they made. The application was also used to gather feedback through small questionnaires.

ELVITEN demonstrates how electric light vehicles (EL-Vs) can be used in urban areas and be integrated into the existing transport network of six European cities.

More detailed information can be found at their website.[7,8]

3.5 Umeå, Sweden

Through the RUGGEDISED project, Umeå[9] is implementing nine smart city solutions to ensure the city achieves two, often divergent, goals: population growth and a lessening of its environmental impact.

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[7] "ELVITEN project." https://www.elviten-project.eu/ (accessed Jul. 25, 2022).

[8] "The ELVITEN EU project demonstrations." https://www.youtube.com/watch?v=JWl-5c6pyXFA (accessed Jul. 25, 2022).

[9] "RUGGEDISED - Smart city lighthouse project - UMEÅ." https://ruggedised.eu/cities/umeaa/ (accessed Jul. 25, 2022).

Often when trying to optimise energy use, the general approach has focused around supply chains and building logistics. Umeå has put a strong focus on its end-users – or citizens who have been ranked as some of the most active and environmentally aware citizens in Europe. But, there is still room for improvement! And the technology that is implemented is only as effective as its users. Therefore, a key aim is to encourage behavioural change, through gamification, as part of enabling a broader social shift in the adoption of more sustainable habits to all aspects of life.

Smart building management connected to the energy demand management system of different buildings in the University District, for which over 500 additional sensors have been installed, has been used to gain a better understanding of power consumption and to lessen the level of unnecessary energy use. On a district level, Umeå has developed different business models to enable buildings to share excess renewable energy and has implemented a system that makes it possible for buildings to store excess heat produced in the wider district. Work here has been useful in developing a more holistic view of the often complex business landscape of energy supply systems – local and distributed – and has provided the opportunity to pinpoint bottlenecks and find ways of mitigating them.

To make sure what follows the increase in population is not traffic jams and lower air quality, Umeå has implemented an innovative approach to parking for the more central parts of the city making it attractive for employers to support sustainable mobility. This, together with the installation of photovoltaics to power electric vehicles without adding burden to the overall energy system and a new climate-smart bus stop, are the approaches for better urban mobility tested in Umeå and have a high potential for replication in other cities.

While data is a universal language, translating it into local climate action remains a challenge. Umeå has developed an open-data decision platform (U8) allowing both city officials, outside experts, and citizens to access and visualise different data from the city; conduct market research in an out-of-the-box solution; and consider a process for presenting data consistently, whilst making sure the portal is sufficiently populated to be useful and ensuring developers of the future are aware of this data source. These are among a number of actions that Umeå has taken to ensuring that urban data is being used to achieve more sustainable, liveable cities.

In summary, the nine smart-city solutions are as follows:

- climate smart business model for 100% renewable energy supply;
- smart peak power control;

- gamification – influence behavioural patterns;
- intelligent building control and end-user involvement;
- climate smart bus station;
- smart city open-data decision platform;
- e-charging hub;
- smart business model for flexible parking;
- smart city open-data decision platform;
- demand side management.

3.6 Tampere, Finland

Fast growth of the city and its event sector and new emerging urban threats underline the need for innovative urban security solutions.

Utilising smart technology (sensors, data analytics, and situation awareness tools) enables:

- to integrate big event areas in the city centre with the surrounding city infrastructure;
- to support collaboration between event organisers, safety authorities, and third-party actors;

The main sources of data for this application come from traffic and analytical city cameras.

City cameras collect video footage from the city centre. The footage is streamed on a real-time basis to Insta Blue Aware (IBA) situation awareness platform[10]. IBA is a web-based tool providing a joint view to safety authorities, event organisers and event safety services, representatives of other safety operators, as well as to city safety management team. Based on the information provided by the camera stream, all actors safeguarding event safety and security can create operating models or act accordingly.

IBA product family includes the following: IBA situation awareness platform, IBT mobile app, and info link.

These solutions (solely or jointly) can be used:

- to support collaboration between authorities and non-authorities;

[10] "Insta - Front runner in secure digitalization." https://www.insta.fi/en/en/ (accessed Jul. 25, 2022).

- to enhance communication;
- to support building and sharing of the "big picture" and situation awareness;
- to enable picture/video sharing where no fixed cameras or other visual connections are available.

All these solutions are:

- easy and light, by using existing technology;
- offered by event city for smooth and safe events;
- scalable through increased amount of sensors, changing/evolving areas, and more functionalities.

AI algorithm that is developed in the Finnish SURE project[11] is able to detect disruptive behaviour from the video footage and in case of any, to send an alert to IBA platform.

3.7 Cities with Universities: KRAKEN and Students

Student data is protected by privacy-preserving cryptography and authenticated using self-sovereign identity solutions.

This pilot allows university students to trade their academic records in a privacy-preserving way, and recruitment agencies to acquire this data and process it, keeping the student's privacy intact.

Universities produce academic data of students, such as graduation certificates, certificates for each course, and the enrolment status for individual terms. With KRAKEN[12], a student can export their data into a cloud data wallet and offer it on a data marketplace. By using privacy-preserving cryptography, such as functional encryption and multi-party computing, a recruitment service provider can purchase a set of student data and use it for analytics, without invading the privacy of individual students. Additionally, KRAKEN uses self-sovereign identity solutions to always ensure user consent and a link between university/student and their data in a privacy-friendly way.

[11] "SURE! TAMPERE." http://suretampere.fi/ (accessed Jul. 25, 2022).

[12] "Education pilot - Kraken." https://www.krakenh2020.eu/pilots/education (accessed Jul. 25, 2022).

Objectives:

- to connect KRAKEN to real university student-information system (SIS);
- to define formats to export and share student data (grades and diploma) in a secure and privacy-preserving way;
- to allow authentication of students via eIDAS (or self-sovereign identities derived from eIDAS identities) to provide user consent;
- to allow authentication of student data by using a decentralised SSI ledger;
- to allow privacy-preserving data analytics on student data using FE and MPC cryptography;
- to demonstrate the applicability of KRAKEN architecture in general;
- to verify that design of KRAKEN components can be applied to a real-world use case.

Benefits and beneficiaries:

- Students: using student data for job applications and allowing to share and demonstrate data in a modular way without compromising the rest of the data.
- University: possibility to exchange student data while ensuring the students' privacy.
- Recruiter: making analysis of student datasets, e.g., gain insight into the academic performance of an individual student by comparing it with analytic of the dataset.
- Companies: facilitating the search for new talent during the selection processes.

Challenges:

Legal challenges: export of student data in a GDPR-compliant way, enabling user consent and privacy.

Technical challenges:

- connect the existing SIS to KRAKEN;
- define formats;
- combine the building blocks provided by KRAKEN to encrypt, authenticate, and analyse encrypted data;

- define data analytics system for the student data;
- connect to one or more data marketplaces;
- connect to the existing or new SSI ledger.

3.8 Rotterdam, Netherlands

One objective of RUGGEDISED is to transform large districts or buildings (old, new, and mixed) into low carbon and resource-efficient districts through smart interaction and integration of energy systems at district level. This requires smart management or infrastructures for electricity, heat, and cold as well as smart solutions for local energy production, storage, and exchange of energy. A representation of available open data of the district of Rotterdam[13] will be visualised on an open 3D platform, making it possible to monitor and communicate different information (starting with the energy performance of buildings), enabling endless applications and scalable to digital city level.

This solution will complement the "energy management system". Data on the energy use of the buildings, provided by the energy management system, will be matched and transferred into a new 3D city operations platform that will be developed.

This platform discloses and visualises the actual use of energy as well as use over a period of time (by individual buildings as well as the whole area). The 3D model is connected to the platform, and together with real-time data, it forms a 3D digital twin of the city.

This forms the basis for further innovation by making data available for everyone. The required infrastructure for this sub-solution is provided separately.

Both the city of Rotterdam as well as private parties will use the model for new applications, also to create new businesses. Connecting the many sensors and other data sources, such as municipal databases, requires standards for connecting to the data platform. The development of such standards is crucial.

Because the entire community will have access to data due to the use of open standards, it is expected that this 3D operations platform will become a powerful resource for further innovations.

The 3D city operations platform is an open data platform. So every third party can use data and visualisation tools to create their own business. This

[13] "RUGGEDISED - Smart city lighthouse project - ROTTERDAM." https://ruggedised.eu/cities/rotterdam/ (accessed Jul. 25, 2022).

will influence society and lead to additional economic benefits for companies and more wellbeing for citizens.

Once developed, the 3D city operations platform can technically be replicated in any city. However, there are a number of conditions for the development of the model and for maintaining effectiveness and availability:

- development and availability of open data standards;
- disconnecting data collection and data storage from application development;
- Data and platform ownership and governance issues;
- Avoiding vendor lock-in.

In addition, co-creation with commercial parties is required for acquiring knowledge and resources.

3.9 Athens, Greece

Athens is a global tourism destination as well as the largest metropolitan city and capital of Greece. Visitor numbers vary considerably with wide differences between the high and low seasons, and these variations have a knock-on effect on traffic within the city.

Athens is a demonstrator city in the DUET project[14] and part of the logic for joining the project was that whilst the city has an overall plan to transform the city, concentrating on digitalisation of services to improve them for their citizens, the city does not have access to vast amounts of readily usable and well-managed data covering the city. So the potential for using a digital twin of the city was recognised, which would have the capacity to bring all of the city's digital sources together and become more accessible. This would create the opportunities for experimentation and exploration in order to maximise the potential in running the city. Athens sees data-driven decision-making as a key pillar for city and business transformation particularly in light of the rapid changing and challenges being faced. Athens is in the early stages of its digital transformation roadmap and is starting from scratch.

Thus, its practical goals in adopting the "digital twin" approach through the DUET project can be expressed as the city wishing to:

- understand city relationships and overcome engagement barriers with stakeholders;

[14] "Athens Twin - DUET: Digital Urban European Twins." https://www.digitalurbantwins.com/athens-twin (accessed Jul. 25, 2022).

- create new business value based on data-driven insights;
- co-create digital services with the active engagement and participation of citizens;
- generate decision-making approach using common standards for greater interoperability of digital tools;
- improve effectiveness of policy design and implementation.

In relation to the city's policy goals, a driving force behind using digital twins is to help achieve the city's overall goals and, in particular, the issue of reducing air pollution.

"Athens is cracking down on air quality, around six per cent of all deaths in Greece are linked to air pollution, towards which diesel engines are acknowledged as a leading contributor, along with a high smoking percentage of the population. With nearly 30 percent of Greece's population living in the capital, having government departments working on transport, health and environmental policies to tackle the issue together seems eminently sensible".

3.10 City Health Organisations and the KRAKEN Health Application

All cities need to care for the health of their citizens and the KRAKEN health and wellness data marketplace for individuals and organisations can assist.

Leveraging the established data platforms of the H2020 MyHealthMyData (MHMD) and Streamr projects, KRAKEN[15] will develop a biomedical data marketplace for individual citizens and healthcare organisations, where it will be possible to commercialise patient medical records and real-world, wellbeing data streams from wearable devices, in full compliance with GDPR.

KRAKEN is developing a biomedical and wellness data marketplace that connects individual citizens and healthcare organisations and shares medical and wellness data streams with data consumers, such as academic research centres, health-tech companies, insurers, public authorities, and wellbeing service providers, in exchange for economic value.

The trading will involve personal health records including lab results, medical histories, and radiology images, and health and wellbeing, real-world

[15] "Health pilot - Kraken." https://krakenh2020.eu/pilots/health (accessed Jul. 25, 2022).

data such as heart rate, dietary, and physical activity, recorded by mobile apps and other wearable devices.

Objectives:

Developing a technical solution enabling citizens and healthcare organisations to:

- fully control what data is shared, with whom, and for what purpose;
- make the data from their devices discoverable to interested parties;
- deliver their data from their devices to those who want it in a simple way;
- receive a share of the value of the data they are producing.

Benefits and beneficiaries:

- Data providers: individual citizens and healthcare centres (hospitals) will be able to control and regulate the use of the data they generate and be equally rewarded for that, increasing awareness of their rights and liabilities as data controllers and sharing the economic benefit deriving from data usage.
- Data users: academic research centres, health-tech companies, insurers, public authorities, and wellbeing service providers. All of them will be able to gain access to high-quality aggregated data for their work in an unprecedented straightforward and seamless way, being able to extract maximum value from data, in turn benefiting society by creating added economic value as well as accelerating the pace of data-driven research and technological innovation in the biomedical field.

Challenges:

- achieving seamless aggregation, curation, and harmonisation of heterogeneous data sources;
- reaching full data interoperability between different systems;
- maximising data discoverability by implementing an efficient data catalogue.
- developing user experiences and interfaces intuitive enough to allow effective utilisation by non-expert users.

3.11 Sofia, Bulgaria

Urban policy-making through analysis of crowdsourced data:
Sofia is the capital of Bulgaria and the biggest political, administrative, cultural, and educational centre in the country, with a current population of 1.8 million inhabitants. The municipality of Sofia is constantly working to improve the urban environment and meet the challenges that the city is facing. Evidence-based policy-making is crucial for addressing urban challenges in a cost-efficient way.

Through its involvement in Policy Cloud[16], the Sofia municipality will address urban policy as a critical success factor in improving the overall urban environment of the city. Policy design will be adapted based on analysis of big data sourced from the following sectors:

- transport, parking, and road infrastructure;
- waste collection and waste disposal;
- cleanliness of public spaces;
- ecology and green systems;
- violation of public order;
- others, of importance to citizens.

In designing policy, we will combine the data from both existing sources and from new open datasets that become available.

The existing data source is the citizens' contact centre, which has been operational since 2014 and facilitates direct communication from citizens, industry, and institutions wanting to signal non-urgent deviations from normal practice within the urban environment.

Analysing the territorial distribution of these signals by category will enable municipal and district administrations to identify problems, issues, and behaviour trends in the urban environment. The analysis will also facilitate monitoring and control of the services under review, enabling preventative action to be taken where potential risk is identified, and guiding decision-making

[16] "Urban policy making through analysis of crowdsourced data - Policy Cloud." https://policycloud.eu/pilots/urban-policy-making-through-analysis-crowdsourced-data (accessed Jul. 25, 2022).

around policy adjustment and/or adoption and also around the effective use of budget and public resources.

Crucially, where policy is introduced or changed as a result of the insights obtained, data analytics will enable the authorities to understand the effects of the change and find explanations for the behaviours observed.

Policy Cloud big data streaming and real-time big data platform will enable the Sofia municipality to improve operational efficiency, transparency, and decision-making.

3.12 Piraeus, Greece

Large commercial districts are vulnerable for both inbound and outbound smuggling, street and organised crime. The city of Piraeus, through the Urban Innovative Actions (UIA) project BeSecure-FeelSecure (BSFS)[17,18], aims to reinforce urban security and promote positive perception of urban safety by providing strategies and tools to link the main urban security stakeholders and facilitate their collaboration in physical-and-cyber space. BSFS offers, among others, a digital platform called Collaborative Urban Risk Management platform (CURiM), enabling the assessment of combined physical cyber threats and the visualisation of risks and other relevant activities through geospatial mapping, to facilitate decision-making. To do so, a wide variety of information is gathered and exploited.

The types of data utilised include:

- information and statistics of crime from the Hellenic Police reports;
- feedback from people through the CURiM mobile application;
- web mining and open intelligence sources;
- sensors.

The evidence-based Collaborative Urban Risk Management (CURiM) ICT platform gathers all available information from multiple sources (CURiM app, OSINT, sensors, and police reports) and facilitates crime risk assessments on selected areas of the city of Piraeus. The analysis investigates the criminality status of the area and helps the decision-making process of the

[17] "Be Secure Feel Secure (BSFS) - Piraeus." https://www.bsfs-piraeus.eu/ (accessed Jul. 25, 2022).

[18] "BSFS Video (English version)." https://www.youtube.com/watch?v=gOP-9bO5LKE&t=4s (accessed Jul. 25, 2022).

responsive action plans that should be followed, in order to mitigate the criminality in the city of Piraeus.

A visualisation component presents/depicts risk assessment metrics providing useful analytics for its users. The CURiM system helps estimate the probability of different urban crimes in different areas of the city.

A crime mapping service/component can visualise the information gathered into a crime heat map for any selected area within the city of Piraeus, thus providing a basic view of the current status as well as the evolution of crime metrics in time.

The information extracted from CURiM is then provided to the Local Council for Crime Prevention (LCCP), recently established in the city of Piraeus. The LCCP brings together local authorities in collaboration with other urban stakeholders to discuss these reports and use this information to prioritise urban security requirements, strategy, and allocation of resources.

3.13 Grand Lyon (Metropolis of Lyon), France

The Metropolis of Lyon is experimenting the My Data[19] approach to allow citizens to monitor their own energy consumption for saving money and reducing their personal environmental impacts. Data is provided by different providers and is stored in the citizen's personal cloud[20] where no external subject can access.

Citizens can store their data related to energy consumption, coming from different operators (gas, water, electricity, etc.) on a personal cloud that can be accessed only by them. From such data, citizens are able to monitor their own consumptions and modify their own attitude to save money and reduce environmental impacts. No external subjects can access citizen's data and the administration is not able to manage it directly: the objective is to make citizens responsible towards the climate change issue by providing them all the necessary information to manage their personal environmental impact.

The access to the personal cloud is free for citizens and is paid by the administration. The service is provided by Cozy[21] which gives to every interested citizen a unique entry point to all available data.

[19] "MyData." https://www.mydata.org/ (accessed Jul. 22, 2022).

[20] "Ecolyo." https://ecolyo.com/ (accessed Jul. 25, 2022).

[21] "Cozy Cloud - Prenez le contrôle de toutes vos données." https://cozy.io/fr/ (accessed Jul. 25, 2022).

The same approach can be extended also to other services, such as finance, insurance, and health.

3.14 Prato, Italy

The experience was carried out in the context of the EU H2020 Project "Raising Open and User-friendly Transparency-Enabling Technologies for Public Administrations (Route-to-PA)".[22] The project objective was the setup of ICT-based tools to improve the engagement of citizens in the open data environment by forming or joining existing online communities that share a common interest and discuss common issues of relevance to local policy, service delivery, and regulation. The project tools allowed citizens both to access open data to activate discussion on public policies based on such data and to produce open data themselves to enrich the city information framework.

The city of Prato tested the project approach in the enlargement of the city Wi-Fi network, by asking citizens to build an open dataset to locate new Wi-Fi access points and to support their proposal through a data-based discussion on the project platform. The result was adopted by the administration as a basis for its policy of improvement of the city Wi-Fi network.

Types of data utilised:

While planning the pilot activities, it was assumed that discussions on this topic might be influenced by several factors, like the population distribution by age and nationality and the dislocation of aggregation points such as sports facilities, libraries, schools, parks, and green areas.

Starting from this assumption, the administration made available several open datasets on the city CKAN platform[23] to support citizens' choices:

- location of the current Wi-Fi network antennas;
- population distribution by age and elementary statistics units (the city is divided into 34 ESU representing the city zones);
- foreign population distribution by range of age and elementary statistics units;
- location of schools;
- location of green areas;

[22] "ROUTE-TO-PA - A Horizon 2020 project." https://project.routetopa.eu/ (accessed Jul. 25, 2022).

[23] https://ckan.org/

- location of libraries;
- location of squares;
- post offices (they are equipped with their own Wi-Fi spots);
- national broadband coverage maps.

Description of the application:

The users logged in the project platform and there could access a specific room where the provided datasets were available for analysis and visualisation, but they also had the possibility of searching autonomously for other information to support the discussion. Through the co-creation feature, the users were also able to build one or more new datasets containing the position and description of the proposed new Wi-Fi locations and to eventually produce a shared document to present their proposal to the administration as a contribution to the Wi-Fi network enlargement.

A moderating role was assumed by the administration, particularly to give information and clarifications if necessary.

The final result was an open dataset collecting all the citizens' proposals that was also added to the open data platform and used by the administration to widen the city Wi-Fi network.

3.15 Eilat, Israel

Eilat is one of the associated counties complementing the 100 net-zero cities.

Eilat's smart city team has developed in collaboration with the chief scientist of the Ministry of Energy, and a local start-up, "Solview", a unique one-stop-shop platform for solar PV installation. It gives each house owner a rooftop view of a financial prediction of solar PV installation.

The data includes calculating the potential surface, expenses, return on investment of future electricity production, finding suppliers, and funding opportunities.

The pilot has ended, and the project is now in the process of updating national and international permits and licenses.

With the help of the citizens' own properties, data, and active participation, this innovative platform will substantially increase the number of efficient PV systems in the city, thus democratising energy and reducing costs and fossil fuel usage.

More detailed information can be found at their website[24].

[24] "Eilat Smart City." https://www.eilat.muni.il/%d7%90%d7%99%d7%9b%d7%95%d7%aa-%d7%a1%d7%91%d7%99%d7%91%d7%94/ (accessed Jul. 25, 2022).

3.16 Florence, Italy

The city of Florence[25,26] has been very active for years in using data to drive decisions and take care of the citizen wellness and environment. The global vision is to employ all currently available data coming from sensors, internal database, and users in order to describe and monitor the city status in every moment; one place to collect, process, and deliver data and information to all the different decision-makers.

The city refers this as virtual smart city control room[27] and a consistent part of it is dedicated to the environment protection.

Even if our data are generated by people's behaviour, they cannot be intended as "personal" data. Some data are coming directly from IoT sensors and others are voluntarily provided by the user through using our city apps[28]. Anyhow, all data that the city uses are every time anonymous and processed in aggregate form.

Data sources include:

- IoT sensors;
- city smartphone application data;
- data exposed from other city players/utilities through API;
- internal data (DB).

The application described relates to tourism: the city uses data of public Wi-Fi network, metro, and city events to monitor and predict the crowding level and prevent congestions in many relevant places inside the city centre. Other than for people, the promotion of the so-called "diffuse tourism" is good for the environment too. The city can better plan and increase efficiency in resource consumption (e.g., improving the availability of public transport just when and where it is actually needed).

Mobility data analysis: coming from different mobility sensors (e.g., number of vehicles in and out from the city, free parking spots available,

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[25] "Firenze digitale." https://www.firenzedigitale.it/ (accessed Jul. 25, 2022).

[26] "#IF2021: la Toscana presenta Smart Region, l'arma in più per gestire i big data - intoscana." https://www.intoscana.it/it/articolo/if2021-la-toscana-presenta-smart-region-larma-in-piu-per-gestire-i-big-data/ (accessed Jul. 25, 2022).

[27] "Snap4City per la creazione di Smart City Control Room, SCCR (ITA)." https://www.snap4city.org/drupal/node/427 (accessed Jul. 25, 2022).

[28] "Smart city & IoT: più dati e meno emissioni." https://www.youtube.com/watch?v=My2d-blBnEVM&t=109s (accessed Jul. 25, 2022).

etc.) in order to estimate presences and road congestion levels. With this non-personal information, decision-makers are able to take actions (over a short and medium term) that can improve the efficiency of the entire mobility system (public and private) inside the city.

Sharing vehicles position analysis: the position of the new sharing electric mobility vehicles (electric bike, scooters, and cars) in order to monitor the distribution across the city and consequently better allocate them to improve their usage.

Through the Infomobilità Firenze (IF) app users can also contribute to share their travel habits in terms of departure and arrival places, preferred vehicle, and street paths. App users can also see the real-time map of all available sharing vehicles and choose to rent one. Once collected, these data help the city to meet the citizen mobility demand, increasing the efficiency and reducing total emission amount.

The project Firenze Green Smart City: an innovative digital project composed of multiple initiatives like:

- a comprehensive digitalised and interactive map of the city green areas;
- smart irrigation: a group of city gardens where the irrigation is completely and automatically handled by IoT sensors;
- a digital platform where citizens can choose to donate new plants to the collection.

Together, these digital platforms, as well as improving or offering new services for citizens, generate new data contributing to better manage, develop, and protect urban green areas.

In relation to the tourism and mobility field, the city is also experimenting on its big data platform with some machine learning models, in order to continuously improve the prediction phase by taking advantage of all the data sources that the city has.

3.17 SmartEnCity: Vitoria-Gasteiz, Spain

One of the three lighthouse demonstrators implemented within the SmartEnCity project is the city of Vitoria-Gasteiz, Spain[29]. An urban management system was designed as the platform where all the information

[29] "Vitoria-Gasteiz urban management system - SmartEnCity.eu." https://smartencity.eu/about/solutions/vitoria-gasteiz-urban-management-system/ (accessed Jul. 25, 2022).

generated in the city can be stored, processed, and retrieved for providing management solutions in the areas of energy efficiency for buildings, urban mobility, and citizen engagement.

The core of the platform includes components like data acquisition layers, data models, data real-time repositories, security, etc. Those data are obtained using low-level sensors measuring temperature, relative humidity, CO_2, gas and energy consumptions, as well as on-board acquisition devices installed on the electric buses.

On the other hand, a city platform was implemented to store and analyse the data gathered from the city and including services offering information on energy consumption and comfort conditions. Citizens have at their disposal specific applications to interact with the platform in a transparent way providing information based on real-time data as comfort conditions, impact calculation of the energy retrofitting of the houses, local news of interest, forecast of energy demand, and high-level visualisation of indicators and key performance indicators online.

3.18 SmartEnCity: Tartu, Estonia

Another example of the implementation of the SmartEnCity concept was developed in Tartu city[30], consisting of the installation of smart home systems in each of the apartments of a specific area, for collecting energy consumption data. The data will be used for improving the configuration of heating and ventilation devices in the renovated buildings, providing end-users with direct feedback about their consumption habits and for building up innovative services by third parties, always assuring the privacy of the end-users.

The technical components of those smart home systems include gateways for communication with the meters, sensors and devices, tablet control panels, smoke detectors, impulse counters, smart thermostats, and CO_2 detectors.

The benefits that the citizens obtain, among others, are the possibility of monitoring and adjusting energy consumption, improved data availability and new business opportunities, increased comfort and control over the indoor climate, behavioural change related to consuming energy, increased energy efficiency and reduced energy bills, greater transparency of urban processes, and better management of service providers.

[30] "Smart home solution (Tartu) - SmartEnCity.eu." https://smartencity.eu/about/solutions/smart-home-solution-tartu/ (accessed Jul. 25, 2022).

3.19 Helsinki, Finland

Digital twin and air quality:

The digital twin for mobility is part of the development of the city of Helsinki's digital twin and the digitalisation of the city in general[31]. The urban environment is a complex entity, with data on it scattered across a large number of different information systems. Therefore, the digital twin is a "system of systems" that can contain many different views that serve different purposes. Different use cases require different input data and different tools to make use of that data. New and even surprising combinations of data offer the opportunity to provide added value and new understanding. The full potential of the urban digital twin is not yet known.

The key benefit of the digital twin is the approach it offers: before major changes are made to the urban environment in the real world, the effects of these changes can first be tested digitally. This saves resources and helps build better lives in cities, as the urban environment can be improved through informed decision-making.

The UIA HOPE project explored how urban residents can participate in air quality measurement and how companies can make innovative use of air quality data. Residents measured local air quality in Vallila, Jätkäsaari, and Pakila.

The road dust season has started and air quality is poor in places. Even in Helsinki, limit values are exceeded every year. Traffic is the largest source of emissions.

In Helsinki, 157 volunteers measured air quality in their residential environment using portable sensors in Jätkäsaari, Pakila, and Vallila. The automated sensors used by the residents carried out more than a million air quality measurements during the research period. The measurements were used to determine whether the residents could be involved in air quality measurements and how reliable the results can be obtained by means of crowdsourcing. The measurements also increased the understanding of air quality among the residents. Through the participatory budgeting method, residents were able to vote on measures to improve air quality at the urban level. Furthermore, on the basis of the measurements, residents were able to change their daily routines so that they used routes with cleaner air.

[31] https://www.hel.fi/helsinki/en/administration/information/general/3d/3d

3.20 Glasgow, Scotland

(Associated Country "climate-neutral city")
Smart open data decision platform and central management system:

This solution includes the creation of a query based geo-spatial "data-based decision platform" (DBDP)[32] that will collect data related to city management (e.g., energy, air quality, traffic flow, etc.) and provide analysis of multiple datasets to enhance strategic planning in the city (including energy planning). Glasgow City Council will utilise the existing open data platform and build DBDP around existing ICT infrastructure. This represents a technical challenge.

The platform will sit on the council's existing platform, gathering city management data. This data will be combined with existing datasets to provide insight into the impact of these smart city operations on services delivered by the council to enhance people's lives. Furthermore, through the monitoring of impacts, targeted interventions can be made in priority areas across the city.

The solution should:

- provide a means to understand the impact of smart city interventions through real-time visualisations;
- provide a means to combine data from smart city interventions with static datasets within the council;
- help non-data "experts" explore the data – real time or otherwise – to help with city planning, stakeholder engagement, etc.

The creation of a DBDP will be an open system for other developments in the city. The platform upon which the tool is built is already at city scale so that little further investment will be required.

[32] "RUGGEDISED - Smart city lighthouse project - GLASGOW." https://ruggedised.eu/cities/glasgow/ (accessed Jul. 25, 2022).